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Comparison of Gait in Patients Following a Computer-Navigated Minimally Invasive Anterior Approach and a Conventional Posterolateral Approach for Total Hip Arthroplasty: A Randomized Controlled Trial

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ABSTRACT: Minimally invasive total hip arthroplasty (MIS THA) aims at minimizing damage to muscles and tendons to accelerate postoperative recovery. Computer navigation allows a precise prosthesis alignment without complete visualization of the bony landmarks during MIS THA. A randomized controlled trial (RCT) was conducted to determine the effectiveness of a computer-navigated MIS anterior approach for THA compared to a conventional posterolateral THA technique on the restoration of physical functioning during recovery following surgery. Thirty-five patients underwent computer-navigated MIS THA via the anterior approach, and 40 patients underwent conventional THA using the conventional posterolateral approach. Gait analysis was performed preoperatively, 6 weeks, and 3 and 6 months postoperatively using a body-fixed-sensor based gait analysis system. Walking speed, step length, cadence, and frontal plane angular movements of the pelvis and thorax were assessed. The same data were obtained from 30 healthy subjects. No differences were found in the recovery of spatiotemporal parameters or in angular movements of the pelvis and thorax following the computer-navigated MIS anterior approach or the conventional posterolateral approach. Although gait improved after surgery, small differences in several spatiotemporal parameters and angular movements of the trunk remained at 6 months postoperatively between both patient groups and healthy subjects. J Orthop Res 31:288–294, 2013

Keywords: THA; surgical approach; minimally invasive; computer navigation; gait analysis

Minimally invasive surgery (MIS) for total hip arthroplasty (THA) aims at decreasing the surgical incision and minimizing damage to the underlying soft tissues to accelerate postoperative recovery.[1] Despite the increase in use of MIS THA, its risks and benefits are still debated in the orthopedic community. A variety of MIS THA procedures exist and they have shown variable results.[2] However, these variable results can mostly be attributed to the fact that some are actually not minimally invasive. There are clear differences between using a conventional THA procedure through a smaller skin incision and using an alternate surgical approach intended to gain access to the hip joint through less soft-tissue dissection and using intermuscular planes. Hence, the term “minimally invasive” is often used for a conventional THA technique performed through a smaller skin incision (i.e., mini-incision THA),[3] without certainty about a reduction in damage to soft tissue.

In contrast with a conventional technique for THA, surgical exposure of bony landmarks during MIS THA is limited. Proper positioning of the hip prosthesis is essential for long-term success, hence some authors recommend the use of computer navigation during MIS THA.[4] Computer navigation allows accurate and precise implant alignment without complete visualization of the bony landmarks during surgery.[5] Although MIS and computer navigation are considered to be potential steps forward in THA, there is a lack of scientific evidence on the effectiveness of computer-navigated MIS THA, especially on physical function. An extensive literature search was conducted for a systematic review on MIS THA, computer-assisted THA, and computer-navigated MIS THA.[3] However, no study with computer-navigated MIS for THA as study contrast was discovered.

Gait patterns of THA patients are characterized by a reduced walking speed and step length.[6–9] Additionally, these patients frequently show an exaggerated lateral bending of the trunk during gait, called a Duchenne limp.[9–11] This decreases the mechanical demand for the hip abductor muscles, by shortening the moment arm between the hip joint and the center of mass of the upper body. Consequently, the mechanical burden on the joint is lowered.[8,11] Moreover, lateral trunk bending during gait can also be used as a strategy for relief of hip pain.[12]

A randomized controlled trial (RCT) was performed into the effectiveness of the anterior approach for THA with computer navigation compared to a conventional posterolateral approach for THA.[13] The anterior approach is a MIS THA technique. Conceptually, the

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anterior approach should cause less tissue damage compared to the conventional posterolateral approach, as intermuscular and planes are used without muscle dissection.[14] With the anterior approach, the musculature for pelvic stabilization remains undisturbed.[15] These muscles play an important role in gait. Since the computer-navigated MIS anterior approach for THA aims at minimizing damage to soft tissue, we hypothesized that patients who underwent THA by means of the computer-navigated MIS anterior approach would show a faster recovery and a faster return to normal gait compared to patients after the conventional posterolateral approach for THA. To test this hypothesis, we determined the effect of surgical technique on gait. Spatiotemporal parameters and frontal plane range of motion of the trunk during gait were assessed by means of gait analysis. Additionally, to determine whether gait was restored 6 months following THA, gait of THA patients was compared to those of a healthy control (HC) group.

METHODS

Participants and Surgical Procedure

Patients between the ages of 18 and 75 who were admitted for primary cementless unilateral THA due to primary or secondary osteoarthritis (OA) were selected. Exclusion criteria were a history of previous surgery to the affected hip, inflammatory polyarthritis where the severity of multiple joint disease was likely to compromise postoperative mobility, and a BMI > 32 kg/m^2. This latter criteria was applied because in obese patients an extensive procedure is needed to gain access to the hip due to the surrounding adipose tissue.

Patients were stratified into three groups based on the Charnley classification,[16] which stratifies patients by the presence of OA in one or both hips or co-morbid conditions that have a negative influence on walking capacity. Within the strata, patients were randomly allocated to undergo THA by means of the computer-navigated minimally invasive anterior approach (MISCAS) or the conventional posterolateral (CON) approach by means of cluster randomization. The random allocation sequence was computer-generated by an independent planner of the local Medical Technology Assessment office.

Patients in the MISCAS group had surgery using the MIS single-incision anterior approach.[1] Two experienced senior orthopedic surgeons performed the MISCAS procedure; both had previously gained sufficient experience with the surgical technique. Advantage of the anterior approach is the possibility of using the intermuscular plane between the m. tensor fascia latae and the m. sartorius, avoiding muscle damage by cutting or detaching muscles. To optimize placement of the acetabular and femoral components, a computer navigation system (Stryker® Navigation System iNstride Hip; Stryker Corp., Kalamazoo, MI) was used. For the conventional technique, a standard posterolateral approach was used. The same acetabular cup (Trident® Cup with X3 or Ceramic inlay; Stryker Corp.) and femoral component (ABG II; Stryker Corp.) were used in the MISCAS and CON groups. The anesthetic, analgesic, and postoperative physical therapy protocols were identical in both groups. Discharge criteria were also identical. No physical therapy following discharge was prescribed, in accordance with the guidelines of the Dutch Orthopaedic Association.[17]

The MISCAS group consisted of 35 patients; the CON group consisted of 40 patients. To determine whether patients' gait returned to normal at 6 months, their gait was compared to that of healthy subjects. Members of several senior citizens' groups and spouses of patients who were included in the study were invited to take part to form the HC group. Thirty healthy subjects without clinical signs of hip OA or other conditions likely to impair gait function formed the HC group. Subject characteristics are presented in Table 1. The local Medical Ethics Committee approved the procedures employed in this study. All participants gave written informed consent prior to testing.

Gait Analysis

Spatiotemporal gait parameters and compensatory trunk movements were assessed by means of a body-fixed-sensor (BFS) based gait analysis. Two hybrid triaxial sensor units were used that contained gyroscopes, accelerometers, and magnetometers (MTx Motion Tracker, Xsens Technologies B.V., Enschede, The Netherlands). One sensor unit was positioned at the dorsal side of the pelvis between the posterior superior iliac spines; the other was positioned on the midline of the upper thorax, just below the spinous process of the 7th cervical vertebra. All measurements took place in a hospital corridor. Gait analyses were performed preoperatively on the day of admission, and 6 weeks and 3 and 6 months postoperatively. Subjects were instructed to repeatedly walk a distance of 25 m back and forth at different walking speeds. Previous research showed that analysis at different walking speeds provides valuable information on (abnormalities in) gait function,[6] and more reliable results are obtained when assessments are made at several walking speeds. Hence, subjects were instructed to walk on a self-selected low, preferred, and high speed. During these measurements, markers were recorded in an additional measurement channel every time the subject passed the 2.5 and 22.5 m point of the 25 m. Previous research showed this gait analysis protocol to be valid and reliable in assessing compensatory trunk movements during gait, as well as spatiotemporal gait parameters.[9]

Table 1. Subject Characteristics

Group	Female/Male (n)	Age (years)	Body Mass (kg)	Height (cm)	BMI (kg/m^2)
MISCAS	24/11	60.3 (7.7)	80.8 (10.2)	172.2 (8.6)	27.3 (3.5)
CON	32/8	60.5 (9.5)	75.3 (12.4)	169.3 (7.2)	26.2 (3.5)
HC	22/8	65.8 (6.0)	69.1 (11.8)	169.4 (9.5)	23.9 (3.2)

MISCAS, computer-navigated MIS THA group; CON, conventional THA group; HC, healthy control group. Values are given as mean (SD).

Data Analysis

As recommended,[18] gait data from the first and last 2.5 m of the walking trials were excluded to assess steady state gait. For each trial, mean peak-to-peak amplitudes of the pelvis and the thorax were determined based on 10 subsequent stride cycles. Stride cycles were selected based on initial foot contact as determined from forward pelvic accelerations.[19] The spatiotemporal variables included walking speed, step length, and cadence (steps/min). Mean speed was determined based on intermarker distance (20 m) and intermarker duration. The peak-to-peak frontal plane ranges of motion (ROM) of the thorax and the pelvis were determined by calculating the difference between the minimum and maximum angles of the segments. In addition, the ratio of the thoracic ROM to the pelvic ROM was calculated. The mean of the back-and-forth walks per instructed walking speed were used for further analysis.

Statistical Analysis

First, to assess whether differences existed in the recovery of gait between the MISCAS and CON group, generalized estimating equations (GEE) analyses were performed (exchangeable working correlation structure and robust estimation of the covariance matrix). Height and body mass were included as covariates in the analyses of the spatiotemporal parameters. Results of all three instructed walking speeds were included in the GEE analyses. Since speed may vary among subjects irrespective of the instructed walking speed, speed was included as a covariate in the analyses of step length, cadence, pelvic ROM, thoracic ROM, and the ratio of the thoracic ROM to the pelvic ROM. Additionally, preoperative values of the outcome variables were added to the analyses, since not adjusting for preoperative differences between the MISCAS and CON group can lead to either over- or underestimation of the intervention effect.[20] Post hoc analyses were performed to determine significant differences in outcome variables among subsequent follow-up measurements. To determine whether significant differences existed in the development of the assessed gait variables over time between both groups, interaction terms (group-by-time interaction) were also added to the analyses. Second, to assess whether patients' gait returned to normal values at 6 months after surgery, differences between the two groups and the HC group were assessed by means of a GEE-analysis. Statistical analysis was done using the PASW software package (version 18; SPSS, Chicago, IL). A p-value of <0.05 was considered to be significant.

RESULTS

Descriptive statistics of spatiotemporal parameters and angular movements of the trunk of the HC, MISCAS, and CON groups are presented in Table 2. Results of the GEE-analyses for differences in the development of spatiotemporal gait parameters and angular movements of the trunk over time between the MISCAS and CON groups are given in Table 3.

No difference in walking speed was found between the MISCAS and CON groups (Group effect). During the follow-up period, walking speed increased significantly (Time effect). The development of walking speed was also comparable between the groups, as no significant group-by-time interaction effect was found. No difference in step length between the two groups was found. After adjusting for speed, no significant change in step length over time was found. No significant group-by-time interaction effect was found, indicating that the development of step length over time was comparable in both groups. Cadence was also comparable. No significant change in cadence over time was discovered, and the development of cadence was the same in both groups, as no significant group-by-time interaction effect was found.

The pelvic and thoracic ROM and the ratio were not normally distributed. This problem was solved after a logarithmic transformation of the data. The data presented in the tables are the back-transformed data. No significant difference in Pelvic ROM was observed between both groups (Group effect). Pelvic ROM increased significantly over time (Time effect). The development of pelvic ROM over time was also comparable, as no significant group-by-time interaction effect was found. Thoracic ROM was significantly higher after THA in the MISCAS group (Group effect). During the follow-up period, no significant change in thoracic ROM was found after adjusting for preoperative thoracic ROM and walking speed. No significant group-by-time interaction effect was discovered, indicating that the development of thoracic ROM over time was comparable in both groups. The ratio was significantly higher in the MISCAS group (Group effect). There was a trend towards a decreasing ratio in both groups over time after adjustment for walking speed. No significant group-by-time interaction effect was found, which indicates that the development of the ratio over time was comparable in both groups.

The results of the GEE-analysis to determine whether the patient's gait returned to normal values at 6 months are given in Table 4. Both groups walked at a significantly lower walking speed compared to healthy subjects. After adjusting for speed, height, and body mass, patients walked with a significantly larger step length, but also with a lower cadence. Pelvic ROM was significantly smaller in the MISCAS and CON groups compared to healthy subjects. Thoracic ROM was significantly higher in the MISCAS group, while no difference was found between the CON group and healthy subjects. The ratio of the thoracic ROM to the pelvic ROM was significantly higher in the MISCAS group, but no difference was discovered between the CON group and healthy subjects.

DISCUSSION

To our knowledge, this is the first study to evaluate differences in the recovery of physical functioning after computer-navigated MIS anterior approach for THA compared to a conventional posterolateral THA technique by means of gait analysis. As in the literature,[6] large improvements in walking speed and step length were observed, irrespective of the approach. However, no differences in the recovery of gait after the computer-navigated anterior approach or the conventional approach for THA were found.

Table 2. Means (SD) of Spatiotemporal Parameters and Angular Movements of the Trunk

	Instructed	Preoperatively		6 Weeks Postoperatively		3 Months Postoperatively		6 Months Postoperatively		
	Walking Speed	MISCAS	CON	MISCAS	CON	MISCAS	CON	MISCAS	CON	HC
Walking speed	Low speed	0.8 ± 0.2	0.9 ± 0.2	0.8 ± 0.2	0.8 ± 0.2	0.9 ± 0.2	0.9 ± 0.2	1.0 ± 0.2	1.0 ± 0.1	1.2 ± 0.1
	Preferred speed	1.1 ± 0.2	1.1 ± 0.2	1.1 ± 0.2	1.1 ± 0.2	1.2 ± 0.2	1.2 ± 0.2	1.3 ± 0.1	1.3 ± 0.2	1.6 ± 0.2
	High speed	1.3 ± 0.3	1.4 ± 0.3	1.3 ± 0.2	1.3 ± 0.2	1.5 ± 0.3	1.4 ± 0.2	1.6 ± 0.2	1.5 ± 0.2	1.9 ± 0.2
Step length	Low speed	58.5 ± 11.1	60.0 ± 9.9	60.3 ± 10.3	59.2 ± 9.5	62.5 ± 11.4	61.3 ± 8.1	65.2 ± 11.2	64.0 ± 5.3	68.6 ± 8.6
	Preferred speed	67.9 ± 15.3	68.3 ± 8.8	70.3 ± 11.4	67.6 ± 10.2	74.7 ± 12.8	72.7 ± 7.8	77.4 ± 9.4	75.1 ± 8.5	79.7 ± 11.6
	High speed	76.1 ± 15.4	75.3 ± 11.4	76.9 ± 11.5	73.3 ± 13.5	83.2 ± 13.5	79.9 ± 11.0	88.5 ± 13.5	82.9 ± 11.1	90.5 ± 11.6
Cadence	Low speed	87.0 ± 11.1	87.5 ± 13.8	80.9 ± 12.4	84.7 ± 11.5	87.1 ± 8.7	90.1 ± 9.8	88.7 ± 8.6	90.6 ± 9.4	102.3 ± 9.4
	Preferred speed	100.0 ± 10.2	100.4 ± 11.4	93.9 ± 12.3	96.7 ± 12.2	99.6 ± 9.6	101.3 ± 7.9	102.5 ± 9.0	101.9 ± 6.3	119.0 ± 16.4
	High speed	106.9 ± 12.6	107.1 ± 10.8	101.3 ± 12.9	103.4 ± 18.5	105.8 ± 11.3	106.4 ± 8.3	107.0 ± 8.9	109.9 ± 8.3	123.6 ± 11.8
Pelvic ROM	Low speed	4.5 ± 1.3	5.0 ± 1.4	3.7 ± 1.4	4.3 ± 1.5	4.3 ± 1.5	4.9 ± 1.4	4.8 ± 1.4	5.5 ± 1.4	6.7 ± 1.3
	Preferred speed	4.8 ± 1.3	5.4 ± 1.4	4.2 ± 1.4	4.6 ± 1.6	5.1 ± 1.4	5.7 ± 1.4	5.6 ± 1.4	6.4 ± 1.3	8.1 ± 1.2
	High speed	5.1 ± 1.4	5.7 ± 1.4	4.5 ± 1.4	5.0 ± 1.6	5.7 ± 1.4	6.2 ± 1.4	6.2 ± 1.4	7.0 ± 1.4	9.5 ± 1.2
Thoracic ROM	Low speed	6.0 ± 1.4	5.7 ± 1.5	5.3 ± 1.5	4.8 ± 1.5	5.5 ± 1.4	4.5 ± 1.5	5.5 ± 1.4	4.4 ± 1.4	4.4 ± 1.3
	Preferred speed	5.5 ± 1.4	5.6 ± 1.4	4.8 ± 1.4	4.6 ± 1.5	5.1 ± 1.4	4.7 ± 1.4	5.1 ± 1.4	4.8 ± 1.4	4.8 ± 1.3
	High speed	5.7 ± 1.4	5.5 ± 1.4	4.6 ± 1.4	4.6 ± 1.5	5.3 ± 1.4	4.7 ± 1.4	5.7 ± 1.4	5.0 ± 1.4	5.2 ± 1.3
Ratio ROM	Low speed	1.3 ± 1.5	1.1 ± 1.6	1.4 ± 1.4	1.1 ± 1.7	1.3 ± 1.6	0.9 ± 1.6	1.1 ± 1.4	0.8 ± 1.6	0.7 ± 1.4
	Preferred speed	1.1 ± 1.6	1.0 ± 1.6	1.2 ± 1.4	1.0 ± 1.6	1.0 ± 1.5	0.8 ± 1.6	0.9 ± 1.5	0.7 ± 1.6	0.6 ± 1.3
	High speed	1.1 ± 1.6	1.0 ± 1.5	1.0 ± 1.4	0.9 ± 1.6	0.9 ± 1.5	0.8 ± 1.5	0.9 ± 1.4	0.7 ± 1.6	0.5 ± 1.3

MISCAS, computer-navigated MIS THA group; CON, conventional THA group; HC, healthy control group. Thoracic and pelvic ROM are expressed in degrees (°), walking speed in m/s, step length in cm, and cadence in steps/min. N.B.: geometric mean (SD) are given of the pelvic and thoracic ROM and of the ratio.

Table 3. Results of GEE-Analyses for Differences in the Development of Spatiotemporal Gait Parameters and Angular Movements of the Trunk Over Time between MISCAS and CON

	Group Effect		Time Effect					
			6 Weeks to 3 Months		3–6 Months		6 Weeks to 6 Months	
	β (95% CI)	*p*-Value	β (95% CI)	*p*-Value	β (95% CI)	*p*-Value	β (95% CI)	*p*-Value
Walking speed[a]	0.01 (−0.06, 0.08)	0.79	0.14 (0.11, 0.18)	<0.001	0.07 (0.04, 0.10)	<0.001	0.2 (0.18, 0.25)	<0.001
Step length[b]	1.6 (−0.4, 3.6)	0.13	−0.2 (−2.2, 1.9)	0.89	0.4 (−0.4, 1.1)	.34	0.2 (−2.0, 2.4)	0.84
Cadence[b]	−2.2 (−4.5, 0.1)	0.06	1.1 (−1.8, 4.1)	0.45	−0.1 (−1.2, 1.0)	0.93	1.1 (−2.1, 4.2)	0.51
Pelvic ROM[c]	−1.1 (−1.2, 1.0)	0.11	1.1 (1.0, 1.2)	0.02	1.1 (1.0, 1.2)	0.04	1.2 (1.1, 1.3)	<0.001
Thoracic ROM[c]	1.1 (1.0, 1.3)	0.02	1.1 (−1.1, 1.2)	.31	1.0 (−1.0, 1.1)	0.58	1.1 (−1.0, 1.2)	0.20
Ratio ROM[c]	1.2 (1.1, 1.4)	0.002	−1.1 (−1.2, 1.1)	0.35	−1.1 (−1.2, 1.0)	0.29	−1.1 (−1.2, 1.0)	0.10

MISCAS, computer-navigated MIS THA group; CON, conventional THA group; β, regression coefficient; GEE, generalized estimating equations; 95% CI, 95% confidence interval. Thoracic and pelvic ROM are expressed in degrees (°), walking speed in m/s, step length in cm, and cadence in steps/min. Reference group: CON. [a]Adjusted for preoperative values, height and body mass. [b]Adjusted for preoperative values, walking speed, height, and body mass. [c]Adjusted for preoperative values and walking speed.

Until now, little research has been done into the recovery of gait after MIS compared to conventional THA,[3] and the few studies that assessed recovery of gait function after minimally invasive THA used a wide variety of approaches[21–24] or compared two MIS approaches.[25–27] Consequently, the results of these studies also vary. Some studies showed no benefit of MIS over conventional THA in terms of spatiotemporal parameters.[21,24] By contrast, Mayr et al.[23] found that, after an MIS anterior approach, cadence, stride length, and walking speed were significantly improved 12 weeks postoperatively, while no significant improvements were found following a conventional anterolateral approach. These findings are in contrast with our findings. There may be several reasons for these differences. First, Mayr and co-workers used a different surgical technique for the conventional THA. Second, they did not adjust for differences in preoperative values of these parameters or other variables that may have influenced the outcome.

Previous research demonstrated that pelvic ROM increased with increasing walking speed in healthy subjects.[28] In our study, pelvic ROM increased significantly during rehabilitation, even more than what would be expected because of the observed increase in walking speed. No difference in pelvic ROM was found between computer-navigated MIS THA and conventional THA. Thoracic ROM and ratio of the ROM were significantly larger in the computer-navigated MIS THA group compared to the conventional THA group, though no differences were found in the development of thoracic ROM and the ratio following THA. Previous research showed that the ratio indicates significant differences between healthy subjects and hip OA patients who showed a Duchenne limp during gait and patients without a clearly visible Duchenne limp.[28] Despite the fact that randomization of the surgical technique was performed after stratification based on the Charnley classification,[16] it might be that the computer-navigated MIS THA group consisted of a larger

Table 4. Results of GEE-Analyses of Differences in Spatiotemporal Gait Parameters and Angular Movements of the Trunk at 6 Months Postoperatively between Patients and Healthy Subjects

	Group Effect			
	MISCAS		CON	
	β (95% CI)	*p*-Value	β (95% CI)	*p*-Value
Walking speed[a]	−0.24 (−0.31, −0.17)	<0.001	−0.26 (−0.33, −0.19)	<0.001
Step length[b]	5.5 (2.5, 8.6)	<0.001	4.7 (2.1, 7.4)	<0.001
Cadence[b]	−7.4 (−11.5, −3.3)	<0.001	−6.8 (−10.5, −3.0)	<0.001
Pelvic ROM[c]	−1.3 (−1.5, −1.1)	<0.001	−1.1 (−1.3, 1.0)	0.05
Thoracic ROM[c]	1.2 (1.0, 1.4)	0.02	1.0 (−1.1, 1.2)	0.52
Ratio ROM[c]	1.5 (1.3, 1.8)	<0.001	1.2 (1.0, 1.4)	0.10

MISCAS, computer-navigated MIS THA group; CON, conventional THA group; β, regression coefficient; GEE, generalized estimating equations; 95% CI, 95% confidence interval. Thoracic and pelvic ROM are expressed in degrees (°), walking speed in m/s, step length in cm, and cadence in steps/min. Reference group: healthy control group. [a]Adjusted for height and body mass. [b]Adjusted for walking speed, height, and body mass. [c]Adjusted for walking speed.

number of patients who walked with a Duchenne limp before THA. Because the development of thoracic ROM following THA was comparable after computer-navigated MIS THA and conventional THA, the difference in thoracic ROM might be a remnant of preoperative differences in thoracic ROM. After surgery, when patients no longer experience pain during stance on the affected limb, patients could still be using these compensatory movements of the trunk because of habit. Additionally, preoperative muscle weakness will not be restored by means of THA. Computer-navigated MIS THA likely does not inflict more damage to the abductor muscles compared to conventional THA, since no muscles are cut or detached with this technique. A cadaver study showed that an MIS anterior technique for THA results in minimal damage to hip abductor muscles.[29]

Six months after THA, all patients still walked at a significantly lower speed compared to healthy subjects. Their step length and cadence were also lower, without correction for several covariates including speed. Several studies showed that deficits in gait biomechanics persist up to a year after THA.[27,30–32] A persistent decrease in walking speed, a shorter step length, and higher cadence compared to HCs were also found.[30,31] However, our study showed that, after correction for walking speed and height, patients' step length was significantly larger compared to healthy subjects. Also, cadence was significantly lower. This difference in findings might therefore be due to the fact that in these earlier studies, no corrections were made for body height and walking speed. Compared to healthy subjects, patients after THA also presented with a decreased pelvic ROM 6 months postoperatively, irrespective of the surgical technique. This "stiff" gait with little pelvic motion in the frontal plane was also observed in other studies on patients at 6 months.[30,33] Furthermore, compared to healthy subjects, the thoracic ROM was also larger, mainly in patients following computer-navigated MIS THA. Consequently, the ratio of the ROM of the thorax to the pelvis was significantly different from healthy subjects in the computer-navigated MIS THA group. Again, these differences might be remnants of preoperative differences, because the trends in pelvic and thoracic ROM over time are the same following computer-navigated MIS THA and conventional THA.

In conclusion, no evidence was found for a faster recovery of gait following computer-navigated minimally invasive anterior approach for THA. Although gait was considerably improved 6 months following THA, small differences in spatiotemporal parameters and frontal plane angular movements of the trunk remained compared to healthy subjects.

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